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having a high dip to the eastward owing to the eastward inclination of the axis of the folds. At North Adams, in the ridge of slate just west of the village, the limestone and slate both dip eastward, there being here the north end of one of the inclined synclinals.

The making of the highest summits of the Taconic region appears thence to have depended on this doubling of the folds. It becomes exceedingly difficult in such cases to ascertain the true thickness of the slate formation.

In view, then, of the facts stated in my former article with regard to the age of the limestone and its overlying rocks, it is not easy to avoid the conclusion that *the Taconic slates are Hudson river slates*, as long since held by the Professors Rogers; and, also, that the rocks on which Prof. Emmons, in his New York Geological Report, first based his Taconic system, or out of which he devised it, are after all nothing but the Hudson river and Trenton groups, with the underlying Chazy. The Trenton limestone and Hudson River or Cincinnati groups, which properly constitute one series in American Geological History, are then *the true Taconic system.*

HINTS FOR THE PROMOTION OF ECONOMIC ENTOMOLOGY IN THE UNITED STATES.*

BY JOHN L. LECONTE, M.D.

It is indeed a most gratifying evidence of the increasing interest in the department of zoology which we cultivate, that the entomologists, now in connection with the "American Association for the Advancement of Science," are sufficiently numerous to form a separate sub-section, and enough in earnest to make the meetings of the section of value to attract our widely scattered students.

I hail with joy the opportunity of being present at this meeting, and the more so, because absence from the country has prevented me from being with you on previous occasions, when you assembled to deliberate on the means necessary for the promotion of our favorite science; to communicate to each other that which you have done of best during the year, and call on your colleagues to rejoice with you over the gems of truth which Nature bountifully bestows on you and on all who visit with pure heart and humble mind her exhaustless treasury.

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*Read at the Portland Meeting of the Amer. Assoc. Adv. Science.

Believing, as I do, that the few days thus spent in closer communion, by those who are in sympathy in their main intellectual pursuits, should be devoted rather to mutual instruction and comparison of general views derived from our studies, than to the reading of essays on special or descriptive subjects, which sooner or later will appear in suitable places in scientific journals, I have thought it not inappropriate to give briefly some ideas suggested by a long course of investigation both in the field and in the museum, regarding the requisites for a more rapid advance of American entomology, and a more speedy development of the practical benefits which the science promises.

Before endeavoring, so to speak, to forecast the future, or to indicate those paths of research from which the most useful results may be expected, it would be well to glance at the past history of our science; so that by rapidly reviewing the steps by which progress has been made, we may be better prepared to estimate the comparative value of the agencies by which our present position has been attained.

The beginning of the American school of entomology may be considered as made in 1817 by Thomas Say, in those days the most generally instructed zoologist in the United States. Though his contributions to the literature of other departments of natural history were quite copious, yet entomology seems to have been his favorite science, and on his studies of the various orders of insects his scientific reputation must mainly rest.

At that time the text-books in entomology were mainly Fabricius, Herbst and Latreille, and the efforts of American naturalists in every branch were confined to adopting, without independent criticism, the classifications and generic determinations of their European correspondents. Biology did not exist either in name or in idea. Careful observations of a few noxious species by Prof. Peck and Dr. T. W. Harris were the slight foundation upon which the whole structure of economic entomology was to be erected.

It will be readily seen then, that the entomologists of that early period were essentially *species men*, namers and describers of the unknown objects with which they were surrounded: — a work which was done so well that of the many hundreds of species described by Say, and the smaller number by his collaborators, scarcely any remain doubtful, and but few unknown.

Preëminent among the early naturalists of the United States, and far beyond any of them, both as an industrious collector, a careful observer in the field, and an intelligent investigator in the museum, was Dr. T. W. Harris, of Massachusetts. A man of singular modesty and diffidence, appreciated neither by himself nor by others, but whose memory will be cherished by all who knew him, and whose merits will be more and more recognized as time brings him with his limited opportunities more strongly in contrast with the other students of his day. Had he published, as he wrote, the independent investigations on classification which he made, or had the proper facilities been afforded him and the requisite stimulus given, our science in this country would have anticipated many of the schemes of arrangement developed later by the best European students.

Among the entomologists of that time, properly pertaining to our country, must be named Dr. C. Zimmermann, a German by birth, and trained to science before he made this continent his home. The monographs of *Zabrus* and *Amara*, published before leaving Europe, still remain thoroughly careful and classical studies of those genera, to which nothing has been or can be added except the descriptions of species since collected. It was a misfortune for our science that Zimmermann too, though a profound and laborious student, would never publish the results of his investigations. As a systematist in the science, he was of the very highest order, and I here cheerfully acknowledge my obligations to him for some of the hints which, afterwards more fully developed, have gained for several of my memoirs the generous approval of foreign entomologists. His manuscripts, submitted to me in 1867 by his widow, contained a large part of a systematic work on Coleoptera, with descriptions of many hundred new species of the Southern States, which, however, had been rendered of no avail by recent publications, posterior to the manuscripts in question.

After the founders of the science in this country came a period of apathy, during which nothing was done. The work of description was then resumed by Melsheimer, Ziegler and myself, without, however, any attempt at independent study of classification or particular observation of life histories of the objects described.

The first serious monographic study made was that of the *Histeridæ*, published in 1845 by my father in the Boston Journal of Natural History, modelled on the *Monographia Histeroidum* of Paykull, and, like it, illustrated with outline figures of all the species.*

The second period in the history of American entomology now begins, in the decade from 1840–50; a most important epoch in the intellectual history of our country. An independent school of science had commenced in zoology by the investigations of James D. Dana on the polypes and crustacea collected while attached to the Exploring Expedition of Captain (now Admiral) Wilkes; in geology by James Hall of the New York Geological Survey, and by the brothers Rogers of the Pennsylvania and Virginia Surveys. Prof. Agassiz also came to us introducing methods of systematic instruction, which previously each student, after many trials, had to invent by himself, and for himself alone; and with his unequalled ability as a lecturer to excite enthusiasm in his hearers, he added a powerful stimulus to the cultivation of natural history, the effects of which can hardly be exaggerated. With few exceptions, the zoological students who have since become prominent in the United States have been instructed for a longer or shorter period by him; and it has been a frequent cause of regret to me, that my early efforts in science had not been directed by one who could so thoroughly combine kindness in instruction with firmness in criticism; who could so well temper the natural impatience for rapid publication of the young and inexperienced observer, to that calmness of judgment which permits nothing to be published until it expresses the best results which the author can at that time produce.

Another most valuable auxiliary to science in the United States, belonging to the same decade, was the establishment of the Smithsonian Institution, on a secure basis, and nearly in the form devised by its learned secretary, Prof. Joseph Henry; whereby the funds were employed chiefly in the assistance of investigators and explorers, and in the publication of scientific memoirs.

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*I have purposely excluded from this sketch of American entomology the illustrated work of Boisduval and LeConte on the Lepidoptera of North America. Although the task of collecting material and making notes on the habits of larvæ with many drawings occupied my father, Major John LeConte, for several years, the text of the work and the systematic arrangement, such as it was, were prepared abroad, not at all under his control; and the work was stopped before the completion of the first volume. All the notes and drawings which were to have been used in the study of the Heterocera were retained by his coeditor, and still remain in Europe.

It has long been the privilege of those who labor to *extend* the boundaries of human knowledge to work hard and (in ordinary phraseology) to find themselves: and, until the organization of the Smithsonian Institution, it was their further privilege, in this country, to publish at their own individual expense all memoirs, which from bulk or cost of illustration were beyond the limited means of local scientific societies.

Under the fostering influence of this, among the most noble of the intellectual charities of the age, many valuable works on abstract science have been published; which, though produced in less than one-third of a century, by a small number of investigators, thinly dispersed over a large extent of territory, would do honor to older communities, in which students of science and their labors are not unfrequently cared for by the protecting influence of government.

It has thus come to pass that manuals and catalogues of several orders of insects have been prepared by the students best qualified to give, in a condensed form, compilations of the latest results of investigation, or entitled to put forth their own views of classification, as worthy of acceptance; and in the preparation of this series of works, valuable assistance has been rendered in orders which had not received attention from our native students, by some of the best European authorities on those subjects, among whom are specially to be remembered with gratitude Hagen, Loew, Osten-Sacken and De Saussure.

The excellence of the memoirs thus published by the Smithsonian Institution results from two facts; the persons invited to prepare the work are those who are recognized by scientific men as most competent for the labor; and the memoirs when prepared are submitted to committees capable of judging of their value. Neglect of these precautions will probably ensure greater or less failure in attempts to procure works for either primary or advanced scientific instruction; and I am the more confirmed in this opinion by the miserable result attending the munificent expenditure of the state of New York, on the volume illustrative of insects injurious to agriculture. Compiled by a person ignorant of the science, and illustrated by a draughtsman untrained in natural history drawing, it remains a permanent example of misplaced confidence and liberality; an equal disgrace to the legislation, the science and the art, of the great state in which it was published.

The possibility of acquiring some knowledge of our insects, without the possession of large costly libraries which up to this period were indispensable, soon made the science more popular; and the names of the species beginning to be known, many persons were attracted to form collections, and others to the equally fascinating study of the life history of individual objects.

Thus arose the present condition of economic entomology; and the biological studies commenced years before by Dr. Harris were worthily continued by Dr. A. Fitch of New York, and the state entomologists afterwards appointed in several of the Western States.

Most prominent among those to whom we are indebted for the development of practical entomology was the lamented B. D. Walsh, of Rock Island, Illinois; an Englishman by birth, bringing to this country a mind well trained in classical and scientific instruction by a thorough University course, and animated by an enthusiastic love not only for science but for truth and consistency in life.

The "Practical Entomologist," a monthly magazine, published (1865 to 1867) by a committee of the entomological society of Philadelphia, was edited chiefly by him. Its successors, the "American Entomologist" and "American Entomologist and Botanist," of Saint Louis, were edited by Mr. Walsh, and Mr. C. V. Riley, the accomplished state entomologist of Missouri. These volumes will be often referred to, not only for the meritorious essays on injurious insects and for the excellent suggestions towards controlling these pests, but still more for the fearless and caustic manner in which the editors exposed many quack contrivances for exterminating our insect enemies; thus endeavoring to protect our too credulous farmers against the pretensions of ignorant inventors and shameless empirics.

Last to be mentioned, because the most recent, of the aids for the cultivation of entomology, and for popularizing the science, is the "Guide to the Study of Insects," by Dr. A. S. Packard, Jr.; a most judicious and excellent compilation from the best works on the various orders, adapted to the North American fauna, and illustrated with copious and well drawn original figures, combined with no insignificant portion of the author's own investigations, chiefly in embryology.

Having now shown, by a hasty survey of the past, the gradual progress of our science, let us consult in regard to what is to be done to perfect the structure, the foundations of which are thus securely laid, and above all, what is necessary to popularize and utilize the great mass of information which has been obtained by so much labor.

Of all the branches of zoology, there is none more intimately connected with the great agricultural interests than entomology;* and yet from the vast number of objects involved in the study, many of which, on account of their small size, are with difficulty recognized by the untrained observer, and also from the complication of metamorphosis and habits such as are seen in no other department of the animal kingdom, there is no branch of natural history which requires for its elucidation greater industry, or higher powers of scientific analysis. For the same reasons, none of the inferior animals are so well fitted to elude and resist human control. We may therefore expect the practical application of the abstract truths and facts contained in the science to be a task of more than ordinary difficulty, requiring the assistance of the most learned students and the most ingenious investigators.

I may, perhaps, be accused of uttering a very vapid truism, when I assert that before any science is capable of rational practical application, the science must be well advanced, or at least its general principles and methods of investigation firmly established; and further that the application must be made by those who are fully informed as regards the science. Yet, by neglect of this apparent axiom, we have seen that the great state of New York expended a sum of money, almost sufficient to print all the useful books on entomology since published in the United States, upon one quarto volume, which is a monument only of presumption and ignorance.

I may be excused, then, for mentioning first those things which in my opinion will contribute to a more rapid advance in the descriptive and systematic portions of our science, and conclude with those relating to its future usefulness.

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*"The entire sum expended by Congress, or by our various State Legislatures for this purpose (from 1776–1869) cannot exceed $90,000 to 100,000, or about $1,000 a year. Yet the annual damage done by insects within the limits of the United States cannot be less than ($300,000,000) three hundred millions of dollars. Am. Entom. and Bot. ii, 109.

"Napoleon, at the summit of his prosperity, never inflicted more damage on a nation than the liliputian insect army inflicts on the United States." *Ibid.*, ii, 367.

First, then, will come the completion of the series of works, published by the Smithsonian Institution, on the classification of the several orders. For this students must be found, who will devote themselves to the study of those orders which have been heretofore neglected. This series must be supplemented by synonymical and bibliographical catalogues, and finally by synopses of species in each order to which supplements from time to time must be made, to diminish as far as possible the necessity of reference to other works, and thus place the accurate results of science within reach of persons who can ill afford the costly libraries now necessary for reference.

Second, and equally important, will be the formation of *type* collections for the identification of species. The number of species is so vast, the differences so small, and the multitude of new forms, not yet represented in collections, so great, that the best descriptions that can be written do not obviate the necessity of referring at times to the original types for comparison, and the amount of time, labor and expense saved to students, by having the whole of the information within reach at one place for each order of insects, can scarcely be estimated.

These type collections should be in the possession of the student who can make best use of them for the present interests of science, and on his death, or retirement from intellectual pursuits, should *not be exposed for sale*, or to any other vicissitudes of fortune, but should be given to his successor in science, or placed in some public institution where they will be *most carefully preserved* and *used only for reference.*

The liberality of friends, both at home and abroad, has already made my collection of coleoptera such a type collection, and with the exception of a moderate number of species described in Europe, of which no duplicates can be obtained, and a very small number which I have described from other collections, at the solicitation of their owners, it contains types of nearly all the described coleoptera of America north of Mexico. From the saving of time both to students who visit my collection, and to myself in naming series for correspondents, I cannot too strongly recommend the formation of similar collections in other orders of insects.*

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* As a proof of the earnestness of this recommendation, as well as a duty I owe to those interested in the progress of the science, who have coöperated with me in plac-

The last portion of our subject yet remains to be discussed: the practical application of the great mass of scientific truth which has been thus far gathered in relation to the structure, classification, habits and life history of insects.

Of the immense number of insects which are found in any given portion of the earth's surface, comparatively few are capable of becoming so numerous as to affect plants injuriously. But from time to time, the interference of man in the progress of civilization destroys the balance which previously existed, and insects, before unimportant by reason of their comparatively small numbers, finding the checks to their increase removed, suddenly become very destructive to one or another of our agricultural products. In this case what is to be done? Obviously there are but two courses; the first to abandon the crop, until the insect enemy is reduced by starvation to its former insignificance; the other is to establish, by human intelligence, a system of checks to take the place of the divine machinery which has been interfered with by the same human intelligence. The second is the course that is, and probably will continue to be, generally adopted.

This new system of checks, according to the habits of the insect to be suppressed, may be divided into (1) those requiring personal labor and diligence alone; (2) personal labor assisted by contrivances; (3) automatic contrivances, not requiring personal attention (including the use of poisons); (4) the production of diseases; (5) the introduction of parasites and other enemies.

Under the 1st head may be mentioned the destruction of larvæ of borers by wires, etc.; 2nd, the collecting of plum weevils, potato chrysomelæ, etc., by large nets, and their subsequent destruction; 3rd, sugaring with poisoned food, specially applicable to nocturnal lepidoptera, and the use of fires, or lanterns with a vessel of poison, to attract nocturnal species; 4th, the communication of fungoid disease (like *pebrine*, which affects the silkworm) to other lepidopterous larvæ;* 5th, introduction and preservation of insectivorous mammals, birds, reptiles and insects

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ing their types in my collection, I hereby pledge myself that my collection shall never be sold or divided, but that it shall be placed permanently, where it can be best cared for, and made accessible for the authentication of specimens. And I invite those who are willing to sacrifice rarities, or even uniques in their collections for such a purpose, to send them to me, with the full confidence that they are thus rendering them of more general use than they can be in local collections.

* I am extremely hopeful of the result of using this method. I have learned of an instance in which from the communication of the disease by some silkworms, the whole of the caterpillars in a nine-acre piece of woods were destroyed.

according to the particular indication of the case; and the transportation of parasites known to affect the pest in other localities.*

In the last annual report of Mr. C. V. Riley, Missouri state entomologist, there is a very effective comparison of the ravages made by the gregarious insect pests with the destruction caused by an invading army. The same simile has been frequently used by me in conversation, and has doubtless often occurred to many of you. The application of it made by Mr. Riley is that, if an enemy were to cause a small fraction of the injury which results each year from the depredations of even one of several of our insect enemies, the whole country would resound with a clamor for the suppression of the invaders. The memory of a colossal conflict is, alas! still fresh in our minds, and I desire not to awaken the painful recollections which rest in the bosoms of us all; but leaving out reference to the distressing scenes which we have all witnessed, there was much of the ludicrous, from which we may on this occasion derive profit, or at least the material for carrying our simile somewhat farther.

Putting out of view for the moment the noble patriotism of the uncorrupted and incorruptible masses of our nation, prominent among whom were the great agricultural class, whose interests it is the object of the present inquiry to protect, we all remember vividly the eager struggle of small politicians for staff appointments, of greater politicians, innocent of martial training, for higher commands; the zeal of contractors to furnish supplies for the soldiers in the field (sometimes, as in the case of shaving soled shoes, and shoddy garments, rather aggravating than relieving their sufferings); the general hurry and scurry, and bustle and turmoil, to do everything hastily and with the greatest pecuniary profit.

Why was all this? Was the great glory to be obtained in military service, when man fights man, the stimulus? Is there not equal glory in the more laborious, albeit peaceful combats of science, when man subdues the inorganic or the organic powers which resist his will, and make them subject to his control? Or is it, perhaps, to use a common phrase of the period, because there was money in it?

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*I learn from the 3rd annual report of Dr. W. LeBaron, Illinois state entomologist, that in accordance with ideas first published by Mr. B. D. Walsh, a Chalcideous parasite of a coccus, which attacks the apple tree, has probably been successfully introduced into the northern part of the state, where it was previously unknown. (*Op. cit.* p. 200).

If the latter be a part of the cause of the agitation to which we allude, let us see if the same idea cannot be utilized for our present purpose. There is money, aye, much money, in any well devised scheme for the practical application of entomology to the protection of agricultural interests. First, there is the saving of untold millions in the productions of the country, now destroyed by insect pests. Second, there is the necessity for the expansion and reorganization of the Department of Agriculture, so that it will represent and protect the farmers, to the same extent that the Coast Survey protects the commercial interests of the nation.

In this expansion and reorganization of the Department of Agriculture the controlling power should be the highest scientific ability that can be procured for the place, and the office should cease to be as it has been since its establishment, a semi-sinecure for persons of small or local political influence. New places would have to be created, but with a moderate sprinkling of good working scientific men, many of these might be regarded like other offices, as the spoils of the dominant political party, and the interests of the farmer still be protected. Better would it be, though, if the latter class should demand that the government give them a thoroughly organized, compact, industrious body of the best trained scientific men, to teach them what should be done to control the destroyers of their labor.

There is now lying idle in Washington a great mass of notes on habits of injurious insects, collected by the untiring exertion of Mr. T. Glover, the industrious entomologist of the Department of Agriculture. This material, in its present imperfect form, if arranged under proper scientific supervision, and illustrated by figures submitted to judicious criticism, and then published in the same careful manner as the explorations of the Engineers, the Coast Survey, and other scientific departments of the government, would be of great utility in preparing the condensed reports, which should finally be accessible to every intelligent agriculturist.

One more illustration, and we will dismiss this already somewhat prolix simile of the invading army.

As in all such cases of aggression, it is competent with the higher military authorities to take private property for the benefit of the nation; so, too, a power similar in its results, though less despotic in its exercise, is necessary in our contests with the organic "powers of the air," which attack our fields. How this authority is to be localized and manifested admits of much discussion, to enter upon which would tax your patience, and prolong this discourse far beyond the limits to which I intend to confine it. For the moment, the following may be suggested, with some modifications, as probably feasible in the extreme cases, fortunately few in number, which may be exemplified by such destructive attacks as the army or boll-worm upon cotton ; the Hessian fly upon wheat; Scolytidæ (bark borers) upon pine forests; and the curculio upon plums and allied fruits.

The establishment of a fund, by the assistance of the federal government, state, or county authorities, or by private combinations, from which are to be paid owners of infected crops, which *are destroyed in order to prevent the spread of the infection.* This must of course be done under the advice of intelligent and carefully chosen agents of the authority by which the fund is to be dispensed. The rate of compensation could be easily determined at the end of the season by the average value or yield of similar crops in the vicinity, and should be such a liberal fraction of the full value, as would stimulate the owner of the property to be destroyed to declare the infection at the earliest possible moment, but at the same time not so large as to prevent due diligence on his part to confine the infection within the smallest limits.

Besides these two measures, which I consider of primary importance, there are several others, more easily under present control, by the adoption of which our accurate knowledge of the really formidable insect pests can be greatly increased, and the means for their suppression intelligently and efficiently applied. With a condensed statement of them, I shall conclude my discourse, thanking you for the kind attention with which you have favored me.

1. Reorganization of the Department of Agriculture, on a scientific basis, for the proper protection and advancement of agricultural interests.

2. Preparation of lists of the most destructive insect pests, with condensed notes of what is now known concerning them, that attention may be directed specially to those investigations necessary to complete our knowledge.

3. Coördination and coöperation of state entomologists with the chief of the Department of Agriculture, that they may work harmoniously and intelligently in concert, and thus avoid the waste

of labor now resulting from duplicate observations and repetitions in publication: collateral to this, the publication each year of a brief report containing such important advances made in the science, both at home and abroad as should be made known to the farmers.

4. Accurate calendars to be prepared of the appearance, disappearance and other phenomena of the history of the most injurious insects in different parts of the country.

5. Contrivance of apparatus on a large scale, by which, with the least expenditure of material and labor, the nocturnal species may be attracted by light, and dropped into a vessel containing cyanide of potassium or other poisonous substance.

6. Experiments on the effects of poisons upon the species, the habits of which permit the wholesale application of such means of destruction: especially adapted to nocturnal lepidoptera by the process known as sugaring for moths.

7. Careful study of epidemic diseases of insects, especially those of a fungoid nature: and experiments on the most effective means of introducing and communicating such diseases at pleasure.

8. The preparation by our best instructed entomologists working in concert, of one or more elementary books suitable for use in schools, giving in a compendious form the general principles of the science, and indications for applying the knowledge to practical results.

9. The appointment in agricultural colleges of competent professors of entomology, who have been trained in a scientific school, to fit them for the duty of instruction.

10. The establishment of the means of compensation for compulsory or voluntary destruction of crops infected by formidable pests, as above mentioned.

NOTES ON THE HONEY-MAKING ANT OF TEXAS AND NEW MEXICO.[*]

BY HENRY EDWARDS.

THE natural history of this very curious ant (*Myrmecocystus Mexicanus* Westwood) is so little known, that the preservation of

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[*] Read before the California Academy of Sciences.